# Proximal femoral fractures in centenarians. A retrospective analysis of 39 patients

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A B S T R A C T

*Background:* A corollary of the current population ageing in France is an increase in proximal femoral fractures (PFFs), particularly among centenarians. The outcomes of PFFs in centenarians in France are unknown. We therefore conducted a retrospective study of centenarians with PFFs both to assess: (1) assess clinical outcomes according to geriatric and trauma scores, (2) and to determine whether routine surgery is warranted.
*Hypothesis:* Morbidity and mortality in a single-centre cohort of centenarians with surgically treated PFFs are consistent with previous reports.
*Material and method:* We retrospectively reviewed the data of 33 women and 6 men aged 100 years or over who were treated surgically for PFFs at a single-centre between 2008 and 2014. Of the 39 patients, 15 were living at home and 24 in an institution at the time of the injury. Mean (range) values were 3.30 (0–7) for the Parker Mobility Score, 5.84 (0–12) for the Katz index, and 7.46 (2–12) for the Mini Nutritional Assessment (MNA). Mean time from injury to surgery was 1.7 days (0–12). The 26 extra-capsular fractures were managed by internal fixation and the 13 intra-capsular fractures by hip arthroplasty ($n = 12$) or screw fixation ($n = 1$).
*Results:* After a mean follow-up of $23 \pm 14$ months (6–60 months), 29 patients had died, including 3 within 48 h, 10 within 3 months, and 15 within 1 year. Sequential mortality rates were 33.3% within the first 3 months, 26.9% from months 4 to 9, and 42.2% within the first year. Early dislocation occurred in 3 patients and surgical-site infection in 2 patients. Other complications were heart failure ($n = 1$), confusional state ($n = 2$), pneumonia ($n = 2$), and pyelonephritis ($n = 2$).
*Discussion:* A PubMed search identified five studies of PFFs in more than 10 centenarians, of which only 2 provided detailed information on postoperative general and local morbidity related to the surgical treatment. Our hypothesis was confirmed for 3-month and 1-year mortality rates, which were at the lower ends of previously reported ranges. Local complications related directly to surgery were considerably more common in our study. PFFs in centenarians carry a high risk of death. Despite the absence of a control group, our data support surgery as the best treatment option.
*Level of evidence:* IV, retrospective study.

## 1. Introduction

Proximal femoral fractures (PFFs) are among the most common injuries, and their frequency is increasing further due to the exponential ageing of the population [1,2]. Injuries in centenarians are no longer a rarity: according to the French National Institute for Demographics, the number of centenarians in France has risen from 3760 in 1990 to 22,912 in 2015 and is predicted to exceed 42,000 by 2025 [3].

PFFs in centenarians was first reported by Fabian in 1991, in two patients [4]. Subsequently, larger case-series studies were published [5–9], although none in the French orthopaedic literature. France has one of the highest life expectancies in the world [3]. Consequently, an assessment of outcomes of PFFs in centenarians in France is timely.

We therefore conducted a single-centre retrospective study with aiming to:

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- assess clinical outcomes according to geriatric and trauma scores;
- determine whether routine surgical treatment of PFFs in centenarians is warranted.

Our hypothesis was that morbidity and mortality rates in our French single-centre cohort of centenarians treated surgically for PFFs compared favourably with those reported previously.

## 2. Patients and methods

### 2.1. Patients

Centenarians treated surgically for a per-trochanteric or femoral neck fracture were identified by searching our institution's electronic database, starting in 2004. Patients with peri-prosthetic fractures or tumour-related fractures were excluded. The number of patients meeting our selection criteria was 0 in 2004 to 2007, 2 in 2008, 3 in 2009, 4 in 2010, 6 in 2011, 6 in 2012, 3 in 2013, 5 in 2014, and 10 in 2015.

Thus, we identified 39 patients, 33 women and 6 men, with a mean age of 101.3 years (range, 100–108 years) (Table 1). Mean ASA score was $2.6 \pm 0.61$ (2–4). Dementia (Mini Mental State Examination score < 20) was present in 14 patients (degenerative, $n = 10$; vascular, $n = 3$; or mixed, $n = 1$). At the time of the fall, 15 patients were living at home alone or with help and 24 in institutions (retirement home, $n = 16$; nursing home for dependent senior citizens, $n = 7$; or extended-stay hospital, $n = 1$). Before the fall, mean values (range) were $3.30 \pm 1.65$ (0–7) for Parker's Mobility Score [10], $5.84 \pm 3.19$ (0–12) for the Katz Index of Independence in Activities of Daily Living [11], and $7.46 \pm 2.23$ (2–12) for the Mini Nutritional Assessment (MNA) score [12].

Of the 26 extra-capsular fractures, 9 were A1, 13 were A2, and 4 were A3 in the AO classification [13]. Of the 13 intra-capsular fractures, 5 were Garden I/II and 8 Garden III/IV. Mean time from injury to surgery was 1.7 days (range, 0–12 days).

### 2.2. Operative techniques

The 26 extra-capsular fractures were treated with internal fixation, by a short locked intramedullary nail in 24 cases and a screw-plate in 2 cases. Treatments of the intra-capsular fractures consisted of triple-screw fixation in 1 case, bipolar hip replacement in 10 cases (2 cemented and 8 cementless), and total hip replacement in 2 cases.

### 2.3. Evaluation methods

Data from the clinical and radiological follow-up evaluations were collected at 3 months, 6 months, and 1 year after surgery. Further information was obtained by telephone calls to the referring physician, institution of residence, or family, until 18 June 2016, i.e., after at least 6 months of follow-up in all patients.

### 2.4. Statistical methods

SPSS™ software (V20, IBM, Bois Colombes, France) was used for the statistical analyses. Means were compared using Student's parametric *t*-test. For comparisons of independent qualitative variables, the $Chi^2$ test was used if sample size was greater than 5 in all groups and Fisher's exact test otherwise. Individual Parker score and MNA items were compared by applying the Mann-Whitney test and Student's test for independent qualitative variables. Values of $P \leq 0.05$ were considered significant.

## 3. Results

### 3.1. Complications and deaths

After a mean follow-up of $23 \pm 14$ months (range, 6–60 months), 28 patients had died. Among them, 3 died within 48 h; all 3 were 102 years of age; their total Parker scores were 2, 4, and 2, respectively; 2 of them lived in retirement homes and 1 in an extended-stay hospital. Causes of death were exacerbation of respiratory disease, aspiration pneumonia, and hypovolemic shock, respectively. Of the 25 other deaths, 10 occurred within 3 months, 7 between 4 and 9 months, none between 10 and 12 months and 8 beyond 12 months. Sequential mortality rates were 33.3% for the first 3 months, 26.9% for months 4 to 9, and 42.1% after the first year. At last follow-up on 18 June 2016, 11 patients were alive, the oldest being 111 years of age (108 years at the time of the fracture) and the longest follow-up was 5 years, in a patient who is 105 years of age at the time of this writing.

Early dislocation of a bipolar hip prosthesis occurred in 3 patients. Among them, 2 were managed by conversion to total hip replacement with a dual-mobility cup. In the remaining patient, a Girdelstone procedure was performed. Surgical-site infection developed in 2 patients and resolved after lavage and debridement without changing the implant in 1 patient and with suppressive antibiotic therapy in the other. Prolonged treatment was required for several other complications: heart failure ($n = 1$), confusional state ($n = 2$), pneumonia ($n = 2$), and pyelonephritis ($n = 2$).

In 5 patients, surgery was performed more than 48 h after the injury, for medical reasons. Among them, 3 were alive 21, 40, and 62 months after surgery. The other 2 patients died, 8 and 11 months after surgery. Mortality rates were not significantly different between these patients and those who had surgery within 48 h ($P = 0.68$).

### 3.2. Functional outcomes

Overall, mean hospital stay was 9.5 days (2–28). Of the 15 patients living at home at the time of the injury, 3 returned home, 5 entered nursing homes for dependent senior citizens, and 7 were admitted to geriatric rehabilitation units. All 7 patients who were in nursing homes for dependent senior citizens at the time of injury returned to the same institution. Of the 14 retirement home patients, 8 returned to their previous institution, 5 entered nursing homes for dependent senior citizens, and 1 was admitted to a geriatric hospital.

At the time of best clinical outcomes, the 26 patients alive after 3 months had a mean total Parker score decrease of $0.83 \pm 0.51$ (0–4) and a mean Katz index increase of $0.33 \pm 0.18$ (1–4) (Table 1). We sought for associations linking the various factors, particularly death within 3 months, score values, and living arrangements. When considered separately, living at home, an MNA score > 8, and a Parker score > 3 were not associated with lower 3-month mortality. When combined in a single patient, not living at home, MNA score < 8, and Parker score < 3 were not significantly associated with 3-month mortality ($P < 0.08$).

## 4. Discussion

Overall, our hypothesis was confirmed regarding 3-month and 1-year mortality rates. Peri-operative mortality was at the lower end of the previously reported range. Systemic morbidity was 18%; Shabat et al. [7] and Tarity et al. [9] reported similar complications, in 13% and 26% of patients, respectively. Local complications related directly to the surgical procedure were considerably more common in our population than in earlier studies [5–7,9]. Among them,

**Table 1**
Details on the 39 centenarians included in the study.

| Patient | Fracture type | Pre-operative Parker score | Pre-operative Katz index | Pre-operative MNA score | Systemic complications | Local complications | Parker score after 3 months | Time to death (months) |
|---|---|---|---|---|---|---|---|---|
| 1 | A11 | 6 | 0 | 12 | | | | 3 |
| 2 | A32 | 0 | 12 | 2 | | | 3 | |
| 3 | G IV | 4 | 7 | 8 | Cardiac/electrolyte disorders | | | D9 |
| 4 | A31 | 3 | 2 | 9 | | | | 3 |
| 5 | G III | 7 | 3 | 8 | | | 4 | |
| 6 | A21 | 2 | 7 | 4 | Died on D2, respiratory disease exacerbation | | | D2 |
| 7 | A21 | 4 | 7 | 6 | | SSI | 3 | 21 |
| 8 | A23 | 4 | 1 | 6 | | | | 18 |
| 9 | A12 | 4 | 4 | 6 | Died on D2, aspiration pneumonia | | | D2 |
| 10 | G III | 4 | 4 | 6 | | | 4 | 18 |
| 11 | A31 | 2 | 8 | 8 | | | | 1 |
| 12 | A23 | 4 | 9 | 8 | | Dislocation | | 11 |
| 13 | A11 | 4 | 4 | 8 | Slipping syndrome | | | D19 |
| 14 | G IV | 3 | 9 | 3 | Confusion | SSI | 1 | 8 |
| 15[a] | G IV | 4 | 4 | 9 | | | | 22 |
| 16 | A22 | 2 | 10 | 8 | Pyelonephritis | | | 17 |
| 17 | A11 | 4 | 4 | 9 | | | 1 | |
| 18[a] | GIV | 4 | 1 | 10 | Respiratory disorder | | 5 | 22 |
| 19 | A32 | 3 | 6 | 8 | | | | 12 |
| 20 | A12 | 6 | 2 | 8 | | | 4 | 75 |
| 21 | A21 | 4 | 5 | 5 | | | 4 | |
| 22 | A22 | 6 | 1 | 12 | | | 0 | 12 |
| 23 | GI | 5 | 10 | 8 | | | | 11 |
| 24 | G IV | 4 | 8 | 10 | Urinary tract infection | | 2 | 5 |
| 25 | A12 | 0 | 10 | 6 | Died on D2, hypovolemic shock | | | D2 |
| 26[a] | A3 | 2 | 6 | 9 | | | | 22 |
| 27 | A22 | 4 | 5 | 8 | | | 4 | |
| 28[a] | A22 | 3 | 9 | 8 | Acute coronary syndrome | | | D26 |
| 29 | A23 | 2 | 7 | 9 | | Dislocation | | 2 |
| 30[a] | G II | 1 | 8 | 5 | | | 2 | |
| 31 | A21 | 2 | 2 | 10 | | Dislocation | 0 | 3 |
| 32[a] | A12 | 3 | 8 | 6 | Anaphylactic shock | | 1 | 2.5 |
| 33 | G III | 1 | 10 | 5 | | | | 1.5 |
| 34 | A21 | 4 | 2 | 10 | | | 1 | |
| 35 | G IV | 3 | 10 | 8 | | | 1 | |
| 36 | A11 | 2 | 6 | 6 | | | 4 | |
| 37 | A12 | 2 | 5 | 8 | | | 1 | 4 |
| 38 | G IV | 6 | 3 | 8 | Pneumonia | | 2 | |
| 39 | G IV | 1 | 9 | 4 | | | 2 | |

G: femoral neck fracture type according to Garden; A: per-trochanteric fracture according to the AO [13]; MNA: Mini Nutritional Assessment; THR: total hip replacement; BiHR: bipolar hip replacement; unC: uncemented; C: cemented; SSI: surgical-site infection; Gamma: Gamma nail; Traumax: Traumax plate; D: day.
[a] Males.

four required revision surgery, which produced the expected functional outcome in only 3 patients. A single previous report, by Oliver and Burke [6], provides information on functional outcomes: of the patients living at home at the time of the injury, only 11% returned home after surgery and only 22% recovered their previous walking capabilities. Corresponding proportions in our study were 20% and 15%, respectively.

Our study has several limitations. The geriatric score values indicated marked dependency of the centenarians before the PFF, with a very low total Parker score of 3.3/9 and a Katz index of 5.84/10. The first two Parker score items had mean values of 1.74 (able to get about the house) and 1.30 (able to get out of the house); thus, the patients usually required help to get around in a restricted environment. The very low mean score of 0.2 for the third item (able to go shopping) indicates that most patients were unable to engage in social activities. Most patients (61.5%) were institutionalised and many (36%) had dementia. Consequently, use of the Parker score is open to criticism. The mean value of the MNA score (7.46/13) should also be interpreted with circumspection, as some MNA items reflect mobility and only three two (decline in food intake, weight loss, and BMI) are directly related to nutritional status.

Our PubMed search using the terms 'proximal femoral fracture', 'per-trochanteric fracture', cervical fracture', and 'centenarian' retrieved five reports of studies in more than 10 centenarians (Table 2). In the studies by Forster and Calthrope [5], Oliver and Burke [6], and Verma et al. [8], surgery was performed routinely. Surgery was not performed in 4/23 and 2/23 centenarians studied by Shabat et al. [7] and Tarity et al. [9], respectively. Two reports provide details on the surgical procedures and their complications and on systemic morbidity [5,7]. In all, published reports (including ours) collected 116 cases of PFFs in centenarians; among the 96 fractures for which anatomical descriptions were available, 65.6%

**Table 2**
Main data from published case-series studies.

| Authors | Total number of hips (patients) | Mean time to surgery (days) | Lives at home | Walks without assistance (number of patients) | Walks with assistance | Fracture type | Treatment |
|---|---|---|---|---|---|---|---|
| Forster and Calthorpe [5] | 13 (13) | 1.6 (2–25) | 5 (38%) | NR | NR | 8 T<br>5 C | 8 DHS<br>3 HR<br>2 screw fixation |
| Oliver and Burke [6] | 18 (18) | NR | 7 (39%) | NR | NR | NR | NR |
| Shabat et al. [7] | 23 (19) | 2.2 (0–5) | 4 (17%) | 0 | 13 (56.5%) | 19 T<br>4 C | 17 DHS<br>2 BiHR |
| Verma et al. [8] | 23 | 3.6 | 6 (26%) | NR | NR | NR | NR |
| Tarity et al. [9] | 23 (21) | 0.9 (0–2) | NR | 1 (4%) | 19 (82.6%) | 10 T<br>11 C | 8 Gamma<br>6 DHS<br>6 HR<br>1 screw fixation |
| Our study | 39 (39) | 1,7 (0/12) | 15 (38.5%) | 4 (10%) | 32 (82%) | 26 T<br>13 C | 24 Gamma<br>2 screw-plates<br>1 screw fixation<br>12 HR |

T: per-trochanteri fracture; C: cervical fracture; NR: not reported; DHS: dynamic hip screw; Gamma: gamma nail; HR: hip replacement; BiHR: bipolar hip replacement.

were per-trochanteric fractures and 34.4% were neck fractures. Systemic and local surgery-related postoperative complications are described in only two reports [7,9] (Tables 3 and 4). Respiratory complications and absence of surgical treatment make a major contribution to postoperative mortality. Mortality rates range from 10% to 30% after 1 month, 45% to 50% after 6 months, and 45% to 50% after 1 year (Table 4). Data on functional outcomes were collected in a single earlier study, by Oliver and Burke [6]. Comparisons are limited by the incomplete descriptive data in earlier reports. In particular, as no previous studies used clinical geriatric scores, the only functional outcomes available for comparison were return home and recovery of previous walking capabilities. Findings from our study that agree with previous data include the predominance of women, greater frequency of per-trochanteric fractures, types of surgical procedures, and short time to surgery. Time to surgery ranged from 1 to 4 days and was usually less than 2 days: 26 patients had surgery on the day after the fracture and 4 on the same day. A time to surgery longer than 48 h did not seem associated with an increase in mortality. Despite the advanced age and marked dependency, studies have shown that 20% to 40% of centenarians live at home, in keeping with the proportion of 38% in our study. The proportion of patients able to walk at home with no cane was 0% in a study by Shabat et al. [7], 4% in a study by Tarity et al. [9], and 10% in our study. In these three studies, 56.5%, 82.6%, and 82% of patients, respectively, walked with mechanical mobility aids.

The increase in dependency that followed the PFFs usually required a change in the patient's living arrangements. Thus, of the 15 patients who had been living at home, only 3 were able to return home, and only 8/14 (57%) patients previously in retirement homes returned to the same home. This work confirms previous reports of high mortality in centenarians after PFFs (Table 4). In our study and earlier publications, respiratory disorders seemed

**Table 3**
Postoperative complications in published case-series studies.

| Authors | Peri-operative surgery-related local complications | Systemic postoperative complications | Early postoperative death |
|---|---|---|---|
| Forster and Calthorpe [5] | Haematoma: 1 | NR | 4 (2 due to lower respiratory tract infection) |
| Oliver and Burke [6] | 1 (NR) | NR | 2 (cause NR) |
| Shabat et al. [7] | Haematoma: 2 | UTI: 2<br>Heart rhythm disorders: 1 | 3 (not treated surgically) +1<br>All 4 deaths from pneumonia |
| Verma et al. [8] | NR | | 2 (not treated surgically) |
| Tarity et al. [9] | None | Kidney dysfunction: 2<br>Pulmonary embolism: 1<br>Stroke: 1<br>UTI: 1<br>Dehydration: 1 | 3 (2 not treated surgically) |
| Our study | 2 BiHR dislocations<br>3 SSIs | Heart failure: 1<br>Confusional syndrome: 2<br>Pyelonephritis: 2<br>Respiratory failure: 2 | 3 |

NR: not reported; BiHR: bipolar hip replacement; SSI: surgical-site infection; UTI: urinary tract infection.

**Table 4**
Overall mortality rates after proximal femoral fracture in published studies. Peri-operative mortality was defined as death within 1 week after surgery.

| Authors | Peri-operative mortality (%) | Mortality at 1 month (%) | Mortality at 6 month (%) | Mortality at 12 months (%) |
|---|---|---|---|---|
| Forster and Calthorpe [5] | 4 (31) | 4 (31) | 6 (50) | 7 (56) |
| Oliver and Burke [6] | 2 (11) | 6 (33) | – | – |
| Shabat et al. [7] | 3 (13) | 5 (20) | 10 (44) | – |
| Verma et al. [8] | 4 (17) | 7 (30.4) | – | – |
| Tarity et al. [9] | 3 (15) | 5 (20) | 10 (45) | 16 (70) |
| Our study | 3 (7.7) | – | 15 (38.4) | 28 (71.8) |

the most common cause of early death. This high mortality would need to be compared with mortality in centenarians without PFFs (Tables 3 and 4).

This work is innovative and undoubtedly constitutes a pioneering endeavour that extends work reported at two national SoFCOT symposia [14,15]. Geriatric traumatology is now a full-fledged emergency medicine discipline involving a multidisciplinary team, in which the orthopaedic surgeon plays a pivotal role. Strengths of this study are the single-centre design, consistency of surgical indications, and large number of patients. An original feature is the pre-operative assessment of nutritional status, in compliance with recent recommendations [16–18]. Bearing in mind the above-mentioned caveats regarding the relevance of the MNA, the high frequency of a poor nutritional status is worth noting: 23 (59%) patients had scores in the 8-11 range, indicating a risk of malnutrition and 14 (36%) had scores lower than 8, indicting malnutrition. Mortality rates in these two groups were 26% and 29%, respectively. Only 2 patients had MNA scores greater than 11; one died 1 month and the other 75 months after surgery.

Thus, the key challenge in managing PFFs in centenarians lies in optimising the general health status by correcting fluid and electrolyte imbalances and improving nutritional status. Admission to a dedicated medial/surgical geriatric unit to ensure the prevention and early detection of complications has been reported to improve both survival [19] and function [20]. The influence of age may limit the use of surgery. In comparisons of outcomes in centenarians and younger patients by Forster and Calthorpe [5] and Oliver and Burcke [6], mortality increased steadily with age, as also documented in other studies [21,22] Importantly, early death is inevitable in the absence of surgery. The appropriateness of surgery should be determined with the anaesthesiologists, in close collaboration with the family.

## 5. Conclusion

Mortality is high in centenarians after a PFF. Families should be fully informed of the risks inherent in this event during the postoperative period. Surgical abstention deserves consideration only in patients with very poor general health and severe comorbidities. Patients should receive multidisciplinary care including appropriate nutritional interventions, as poor nutrition is an under-recognised yet common factor in the very old.

## Disclosure of interest

P. Bonnevialle is a research and education consultant for Amplitude, Stryker, and De Puy. N. Reina provides consultancy services unrelated to this work to B Braun. N. Bonnevialle provides consultancy services unrelated to this work to Wright. M. Laffosse provides consultancy services unrelated to this work to Tornier and receives fee for educational services from Stryker.

The other authors declare that they have no competing interest.

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